Performance Study of Disaster-Resilient Mesh Networking using NerveNet Wi-Fi and LoRa

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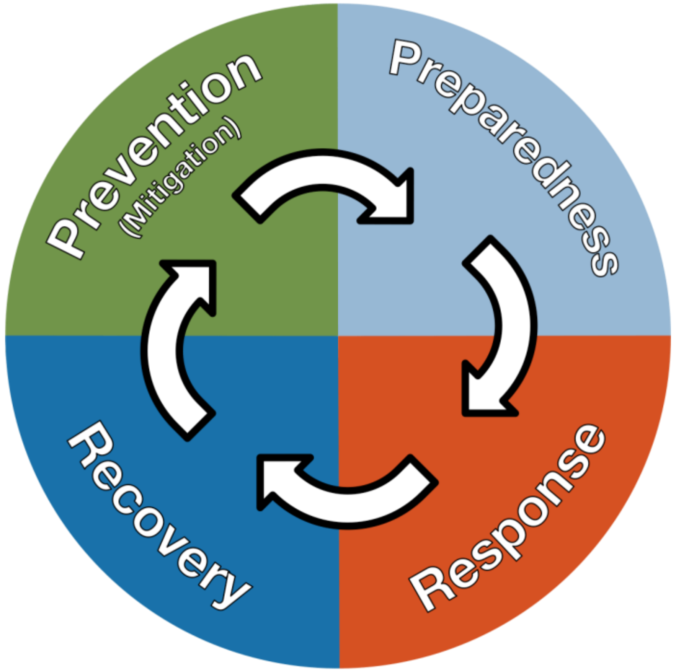
Introduction

- According to [1], the total occurrence of global natural disasters in 2021 is 13 % higher than the average over the last 30 years.
- Four phases of emergency management.



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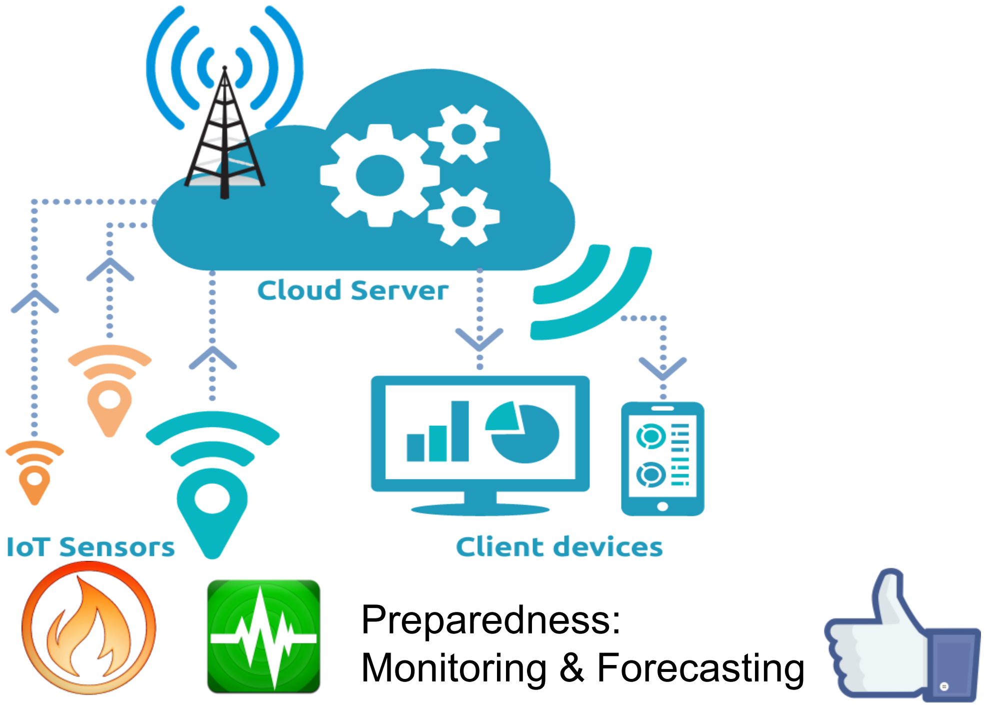
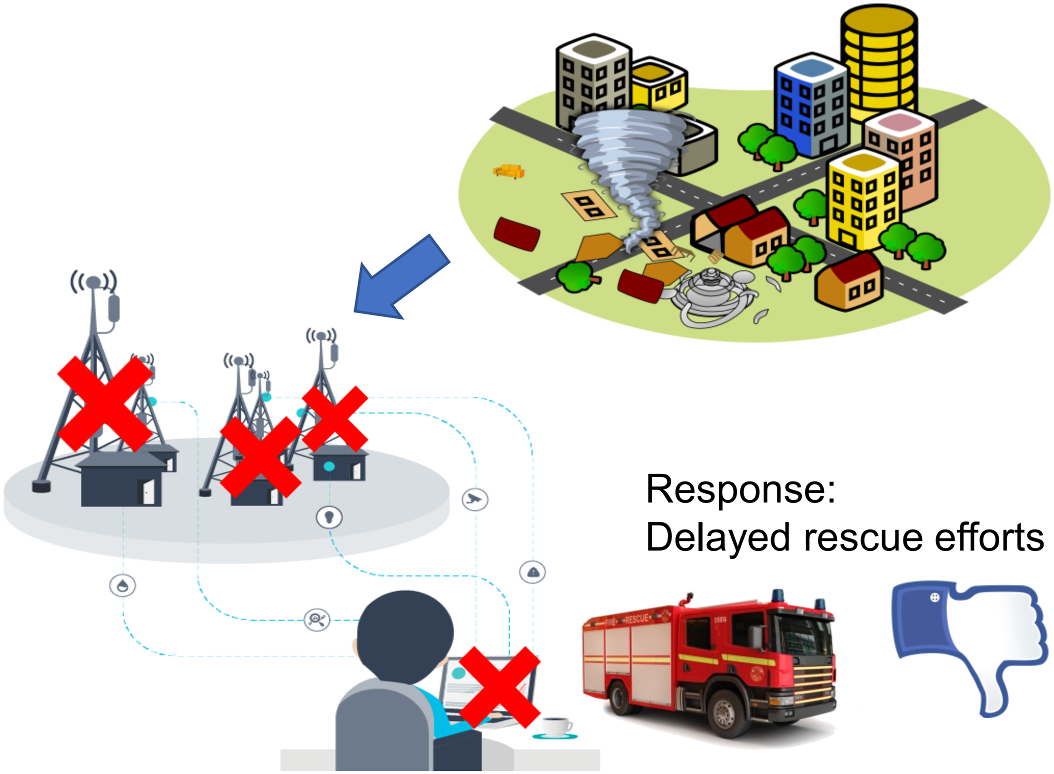
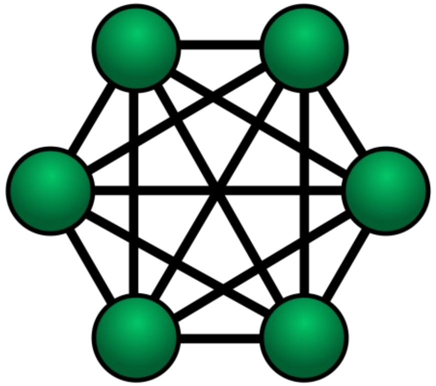
Problem Statement





Limitation: An timely and accurate disaster monitoring framework should consider network resiliency.

Related Work (Wi-Fi Mesh Network)



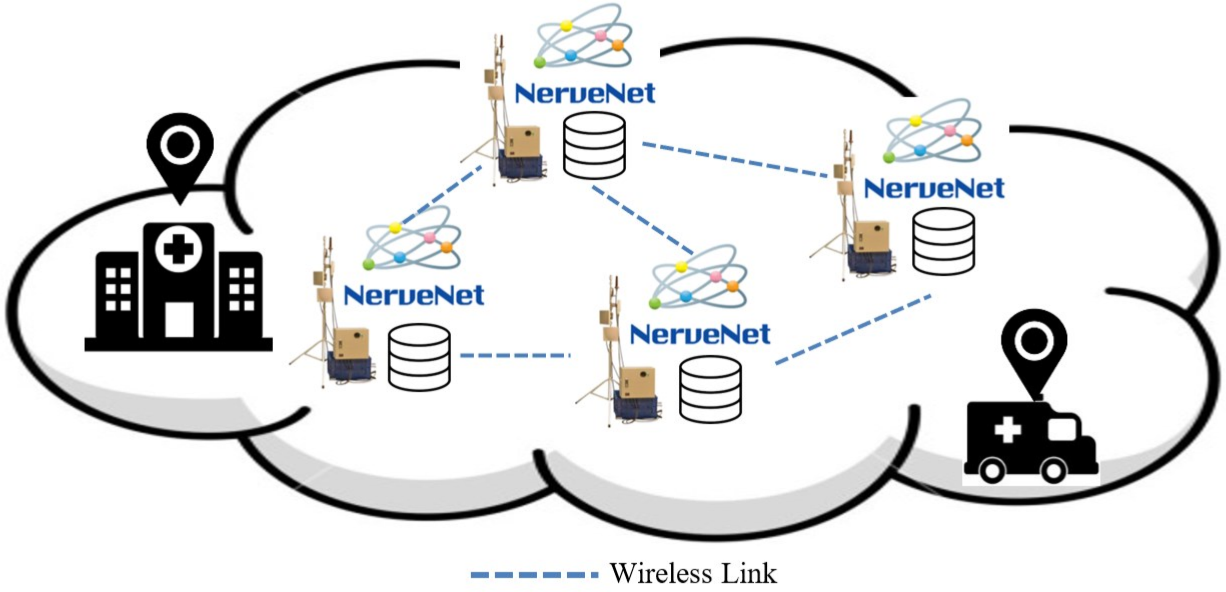
- In [5], the authors proposed an architecture for a drone-based communication infrastructure for disaster response. The drones form a Wi-Fi mesh network to forward the location of victims.
- Similar scheme was presented in [6], where the authors developed a synchronous content distribution system via Wi-Fi mesh networking.
- **Limitation**: The limited transmission range of Wi-Fi presents a challenge for the alert message to be broadcasted effectively.

Related Work (LoRa Network)

- The authors in [7] implemented a device-to-device (D2D) based LoRa MAC solution to disseminate the data. However, it is not based on mesh networking.
- In [8], the work analyzed the performance of unmanned aerial vehicle (UAV)-enable LoRa networks for disaster management applications, from the perspective of ns-3 simulation.
- Recognizing the complementary benefits of Wi-Fi and LoRa, the work in [9] designed a hybrid Wi-Fi LoRa ad-hoc network which leverages smartphones and IoT devices as nodes in a mesh.
- **Limitation**: These works focuses on sharing information via messages, not the images, which provide more insights about the emergency status.

Proposed Solution (NerveNet)

- NerveNet is a specially developed mesh network for the regional area to provide reliable network access and a stable, resilient information-sharing platform in emergencies, even if the base station is destroyed in a disaster.
- NerveNet has the feature of database synchronisation.
- NerveNet supports various communication technologies including Wi-Fi and LoRa communications.



Network Architecture

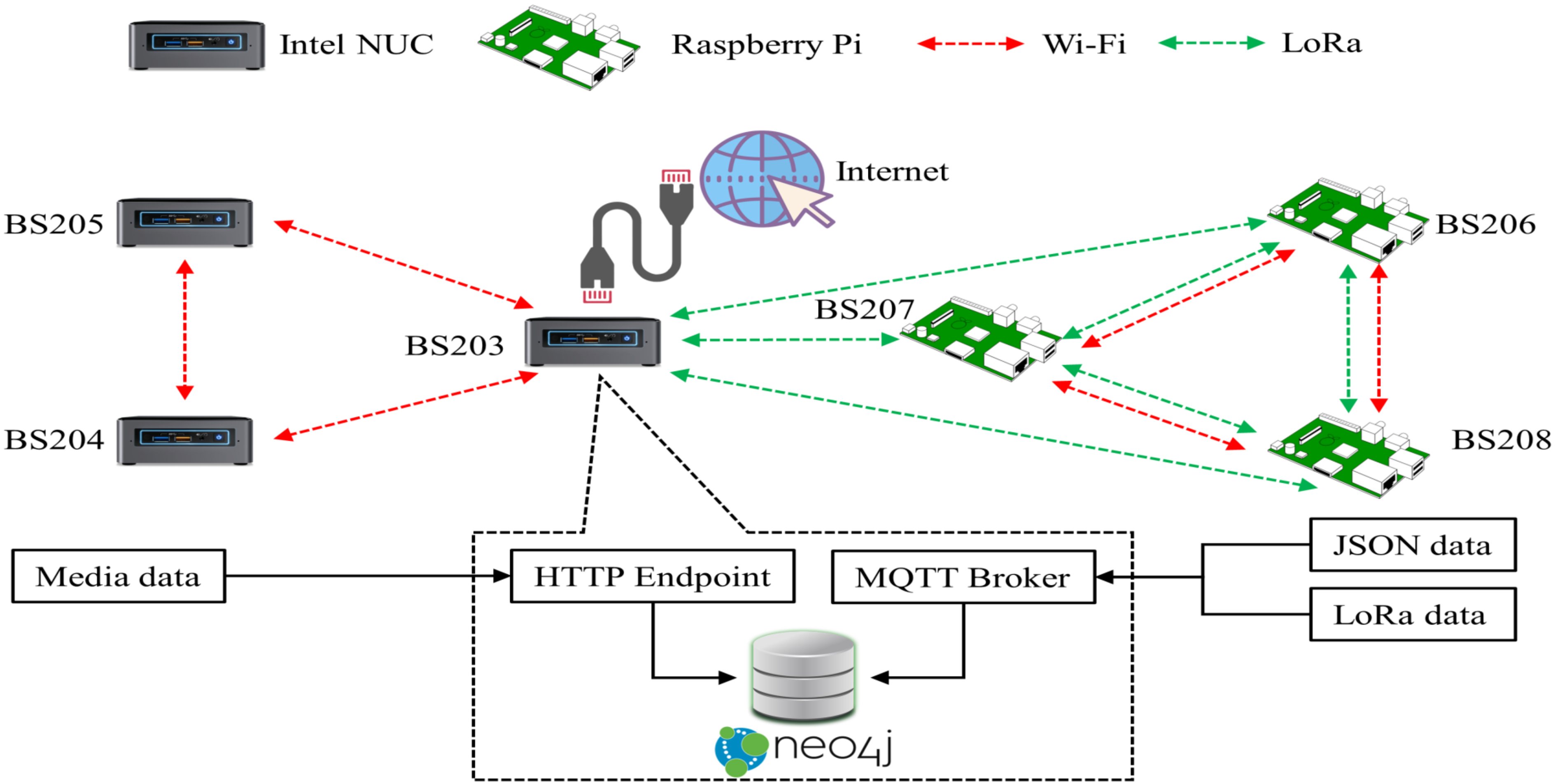


Fig. 1 NerveNet network architecture.

Testbed

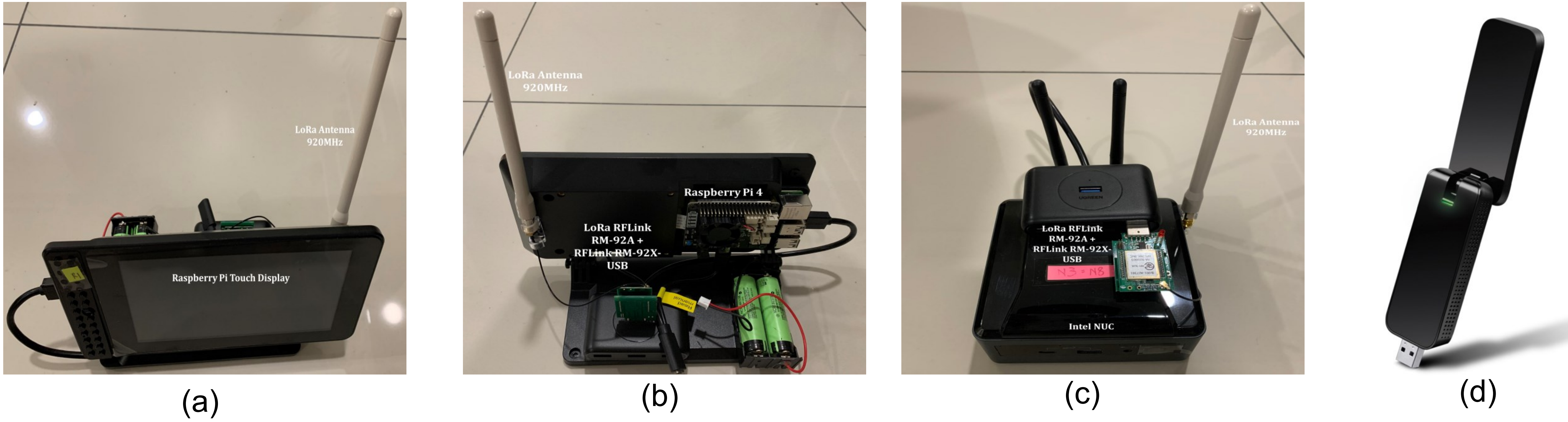
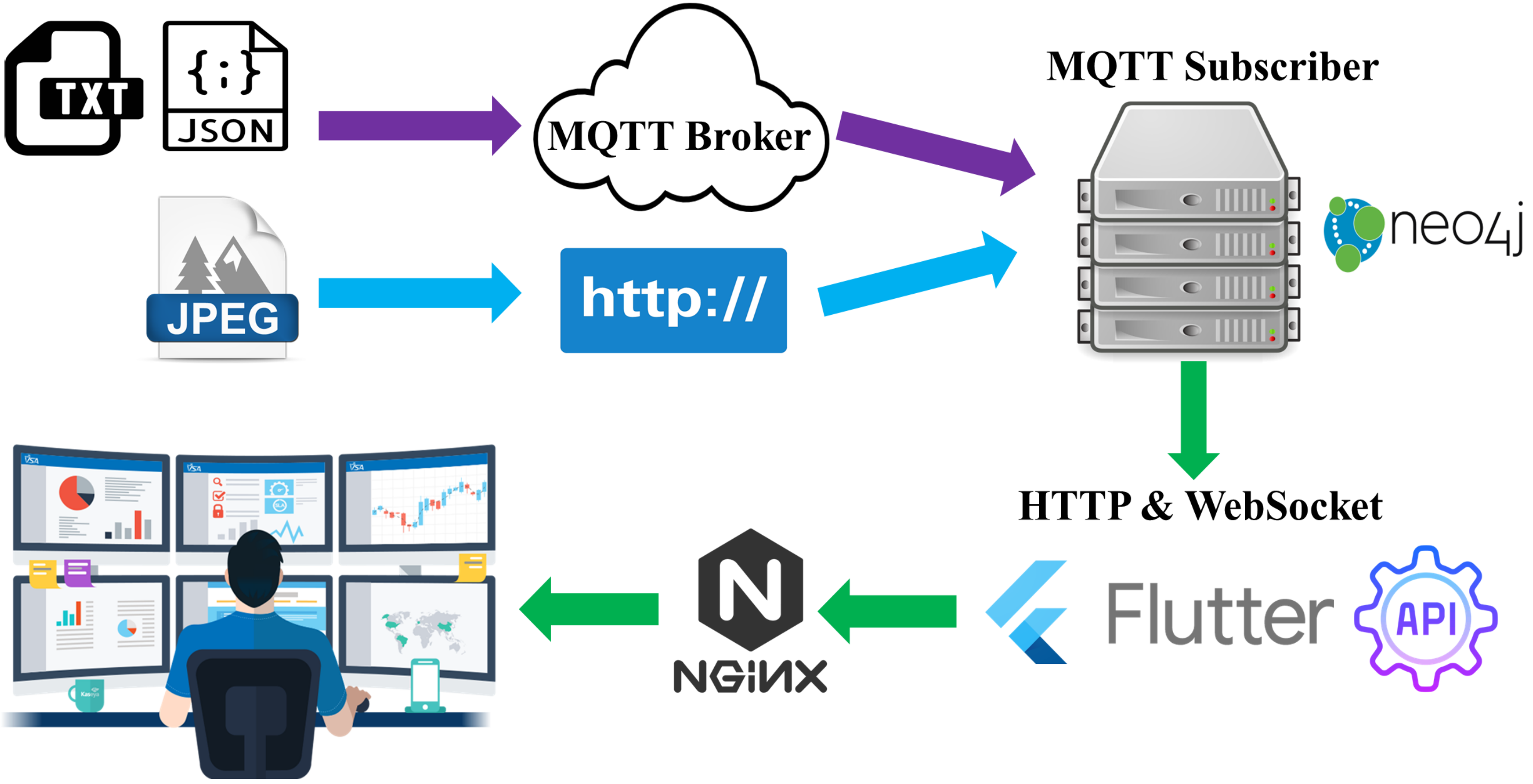
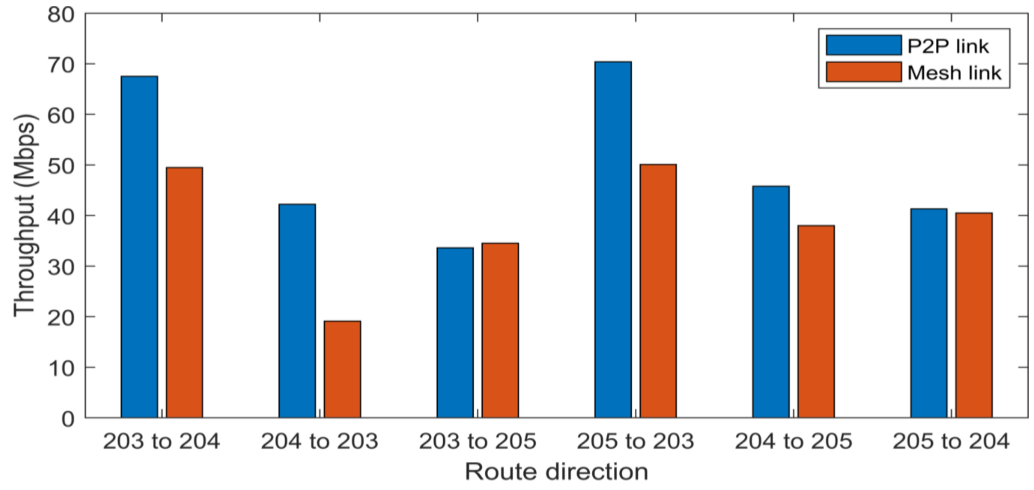


Fig. 2 Testbed. (a) Raspberry Pi 4 (front view). (b) Raspberry Pi 4 (rear view). (c) Intel NUC. (d) TP-Link Archer T4U AC1300.

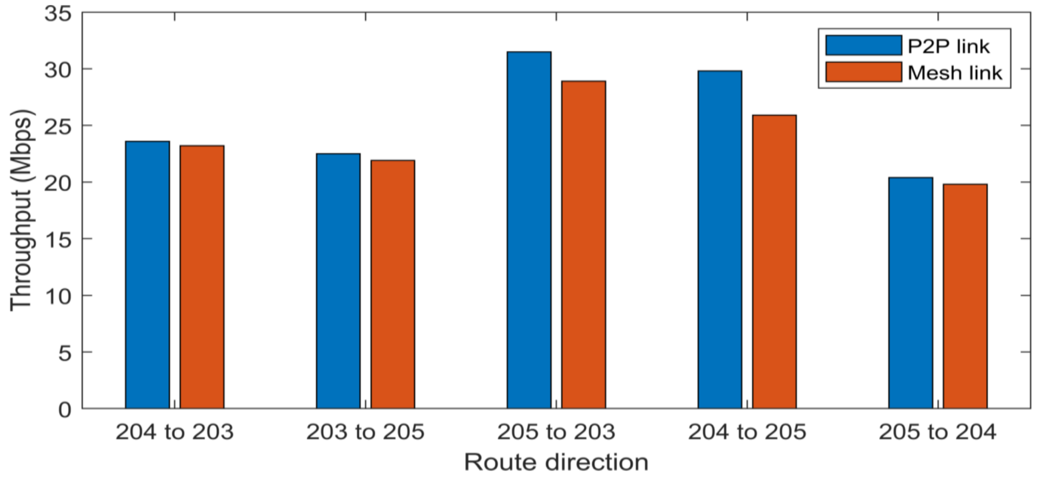
NerveNet Monitoring Dashboard (NerveDASH)



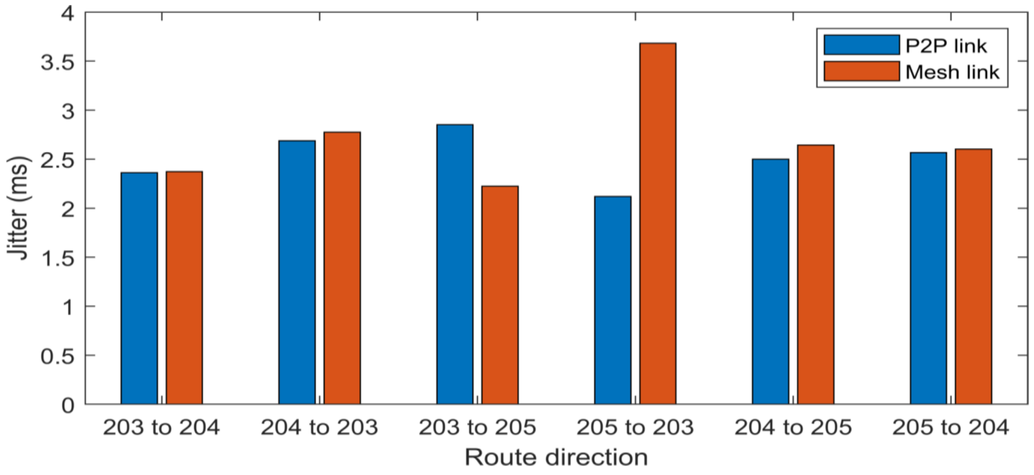
Performance Evaluation (Intel NUC)



(a)



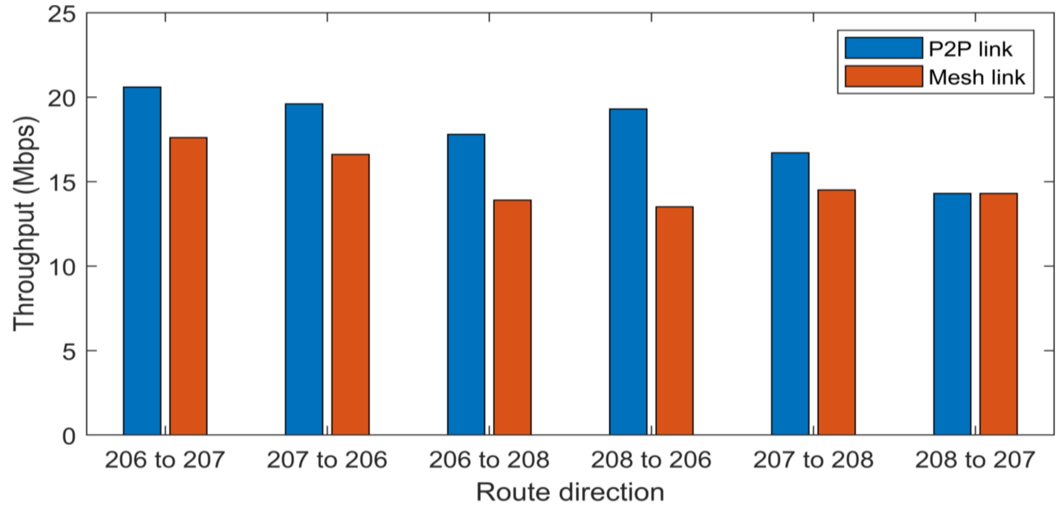
(b)



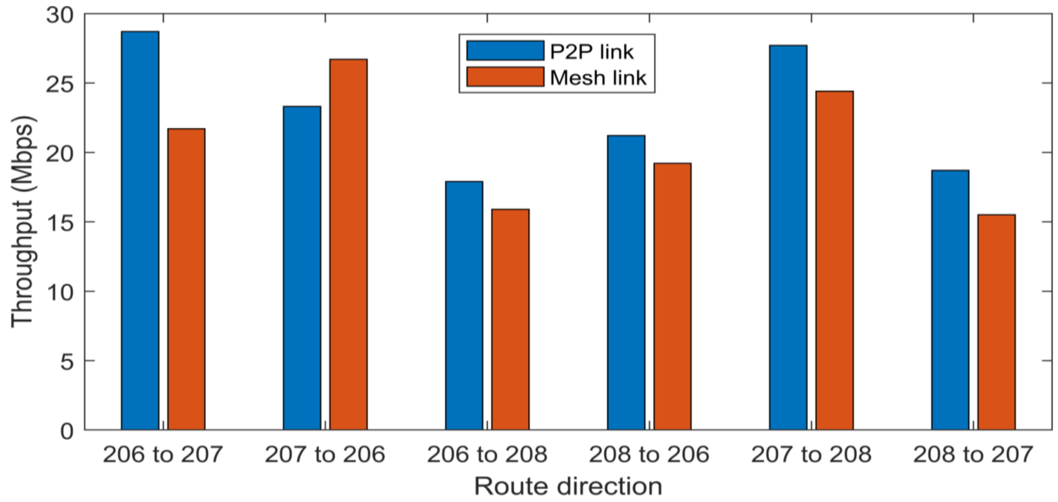
(c)

Fig. 4 NerveNet Intel NUC Wi-Fi. (a) TCP throughput (b) UDP throughput. (c) UDP jitter.

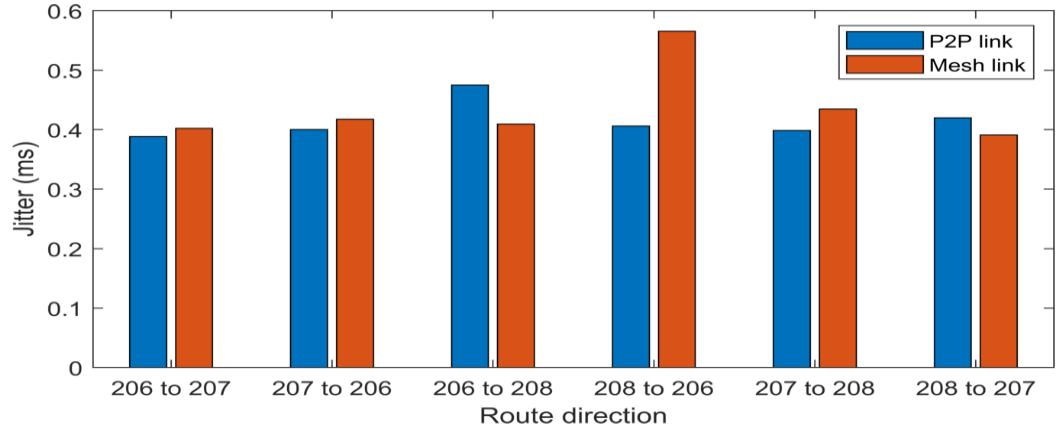
Performance Evaluation (Raspberry Pi)



(a)



(b)



(c)

Fig. 6 NerveNet Raspberry Pi Wi-Fi. (a) TCP throughput (b) UDP throughput. (c) UDP jitter.

Performance Evaluation (Image Synchronization)

TABLE I. IMAGE RESOLUTION AND SIZE FOR DATABASE SYNCHRONIZATION TEST

Image resolution (label)	Image Size
960 x 540 (low)	264.8 kB
1920 x 1080 (moderate)	909.7 kB
3554 x 1999 (high)	2.5 MB
9600 x 6800 (ultra high)	10.9 MB

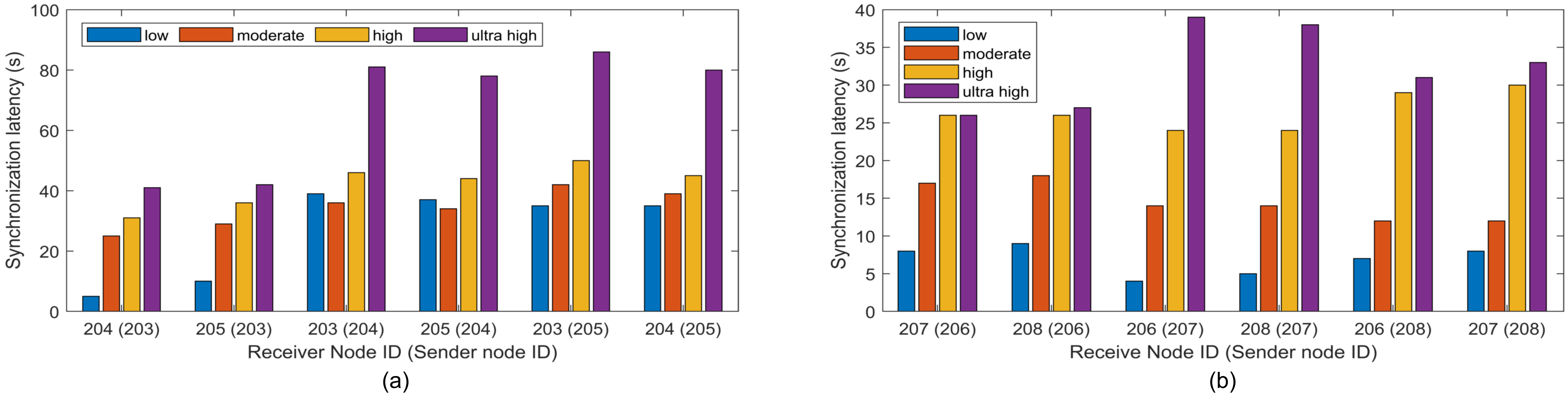


Fig. 7. Time taken for NerveNet image synchronization. (a) Intel NUC (b) Raspberry Pi.

Performance Evaluation (LoRa Transmission)

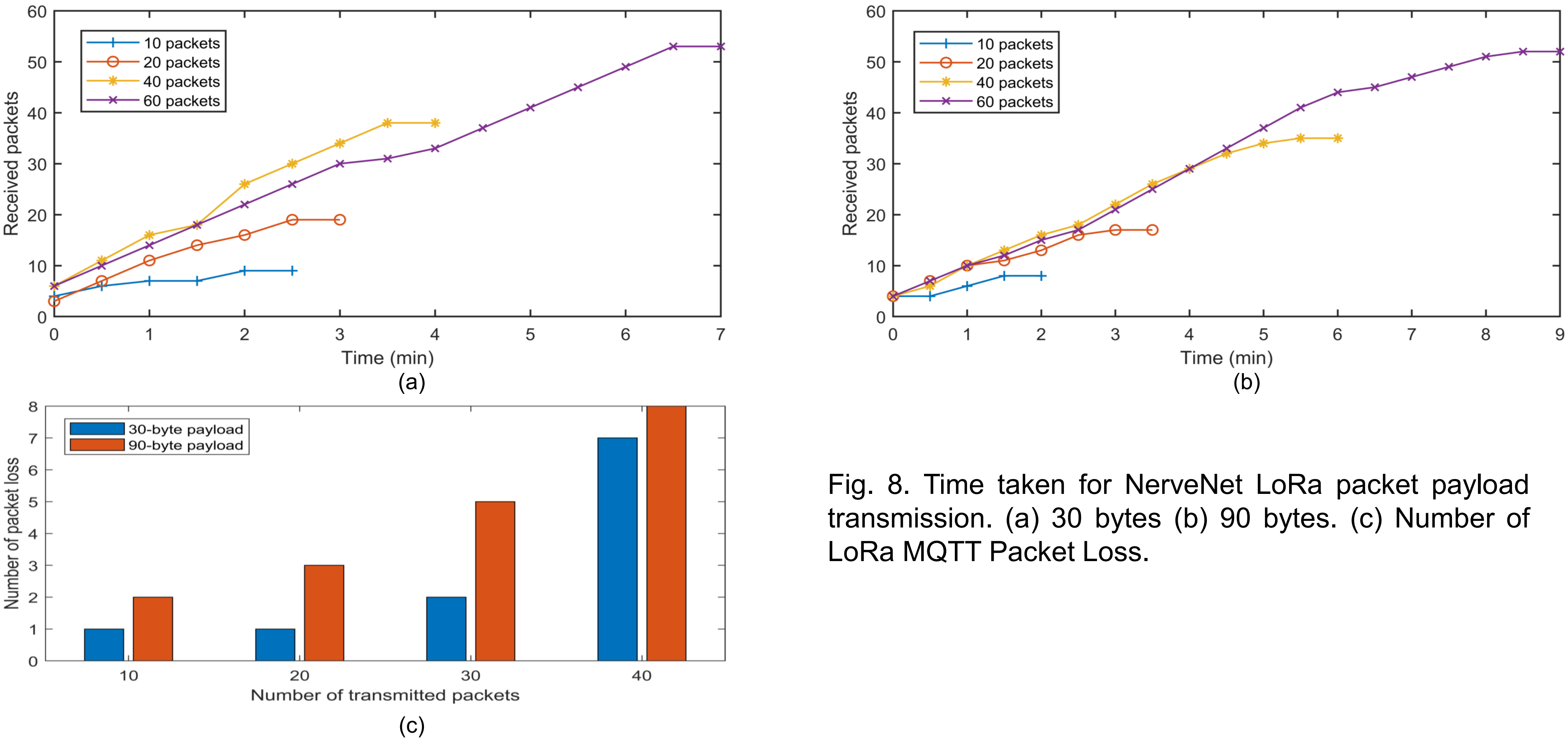
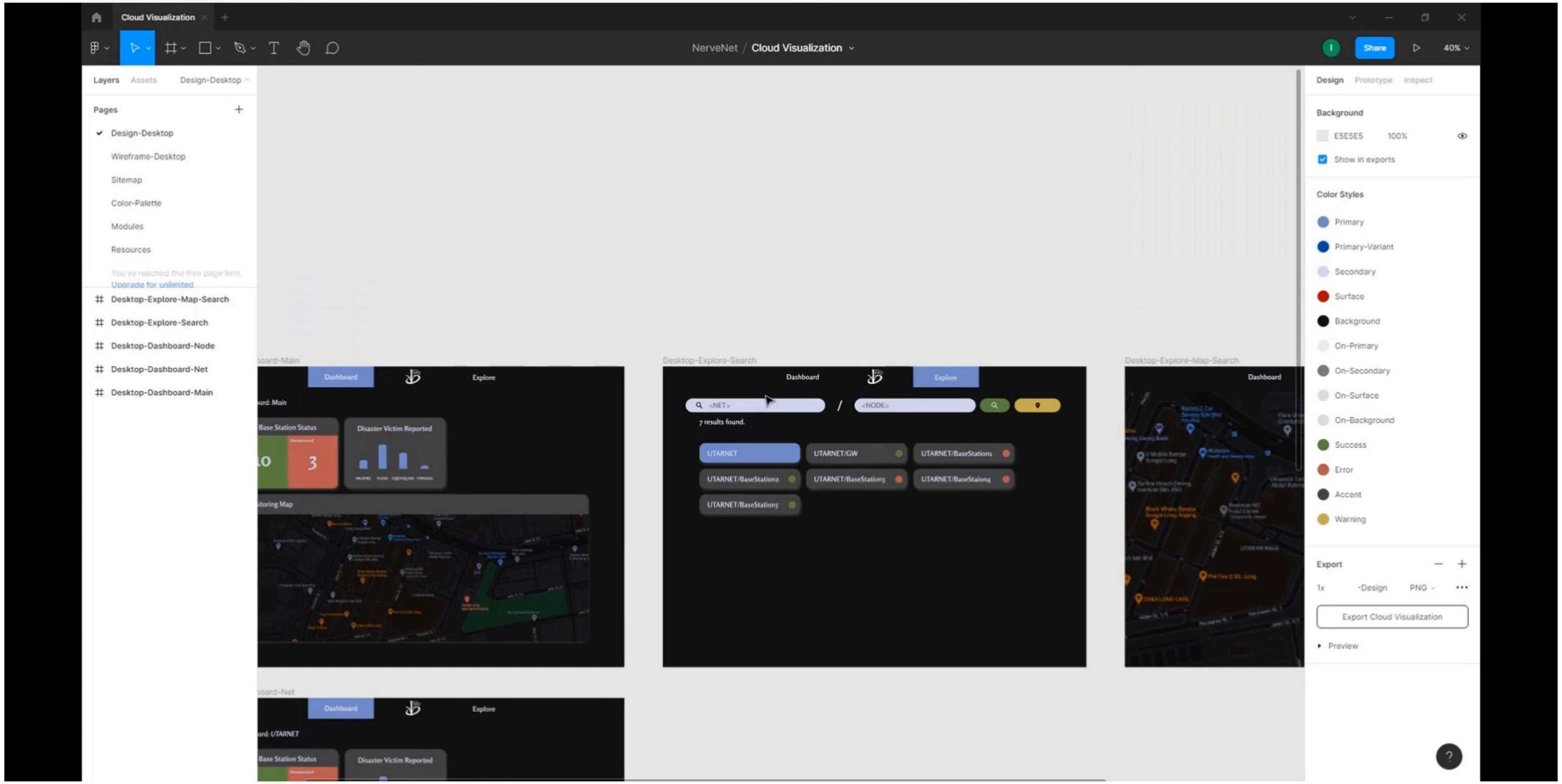


Fig. 8. Time taken for NerveNet LoRa packet payload transmission. (a) 30 bytes (b) 90 bytes. (c) Number of LoRa MQTT Packet Loss.

NerveDASH (Demo)

Frontend Design



Conclusions

- A testbed for disaster response and monitoring platform using NerveNet has been designed and deployed.
- Both Wi-Fi and LoRa has been implemented in the NerveNet system.
- A cloud monitoring dashboard to visualize multiple NerveNet regional response networks has been designed and developed.


Q&A